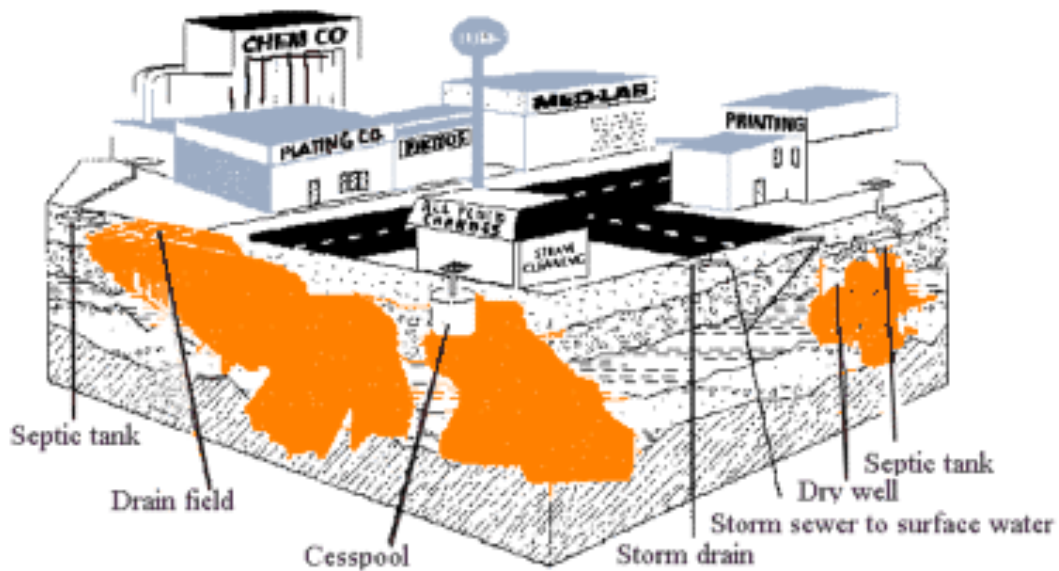


# Distribution of Organic Contaminants in Automotive Waste Disposal Drywell Systems

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## INTRODUCTION

Automotive product waste disposal drywells are identified by the United States Environmental Protection Agency (USEPA) to be a serious threat to the nation's underground sources of drinking water. These drywells, code named 5X28 injection wells, are defined by USEPA regulations (40 CFR Parts 144-147) either as Class V (non-hazardous) injection wells, or as Class IV (hazardous waste) injection wells.

There may be tens of thousands of 5X28 underground injection wells nationwide. When they are Class IV injection wells, they must be properly closed, because underground injection of hazardous waste into Class IV wells is only permitted for the purpose of conducting remediation of contaminated ground water (40 CFR 144.13(c)). Proper closure requires a facility, at a minimum, to cease discharge, plug the drains and piping with cement, and dispose of liquids and sludges. Furthermore, State or local regulations often require removal of contaminated soils and implementation of a ground water remediation or monitoring program. Complete and proper closure thus entails a large expenditure of money by the regulated community, and a large drain of resources by the regulators required to conduct oversight. How to properly close these drywells without overwhelming the regulatory staff or the regulated universe is a problem facing many States.

This report documents a study of ten 5X28 systems where we tried to address this problem by answering the following questions: 1) what types of contaminants are most frequently found; 2) how are the contaminants distributed in the system; 3) and, what is the minimum level of remedial action required to protect the environment while minimizing the cost to the responsible party, a balance necessary in these tough economic times.

## MATERIALS AND METHODS

### Sites

We examined ten sites. They were all fuel and repair service stations for automobiles, located throughout the State of New Jersey. The sites are situated on a variety of rocks, including gneiss, shale, unconsolidated sediments and glacial till, and soil textures range from sand to silt loam.

Typically, a 5X28 drywell system consists of the following components: 1) a floor drain beneath an automobile service area that delivers liquid waste to; 2) an oil/water separator that separates the light non-aqueous phase liquid (LNAPL), such as grease and oil, from the liquid waste; 3) and a drywell (injection well), which is a permeable pit, pipe or leaching field, that allows the discharge into the ground of the mostly LNAPL-free liquid waste (Fig. 1).

### Data collection

Independent environmental consulting firms collected samples of the media contaminated by discharges into the drywell systems at these ten sites. The sampling occurred as a consequence of site remediation activities conducted by the property owners, and there was no coordination of activities by the NJDEP. Thus, the experimental design contributing to the study was not controlled. The contaminated media include the mostly LNAPL-free liquid waste (DWLIQUID), the material that settles to the bottom of the drywell (DWSLUDGE), soils, and ground water (GROUNDWATER). Eight of the ten sites were evaluated by the same firm, and all the sites were investigated using similar protocols based upon USEPA policy. However, consultants did not always use a consistent approach to select the media to sample at the different sites. For example, DWLIQUID and DWSLUDGE were sometimes collected separately, and sometimes composited. Furthermore, as shown in Table 2, the contaminated media selected for sampling by the consultants varied from site to site. These inconsistencies limited our ability to compare sites.

Costs to remediate 5X28 sites were determined by considering a combination of real costs and results of a cost model. Consultants provided real costs for drywell closure but this data were often inflated due to costs of remediating contamination originating from other sources, such as underground storage tanks (UST's). We developed a cost model to remove this inflation and to estimate the costs of closure options not implemented at these specific sites. Cost data were obtained from Mahoney (1989), from consulting firms, and from personal communication with representatives from the NJDEP. Cost data were adjusted to account for inflation and for

health and safety requirements. The cost data projected by this model generally agree with the actual data reported by the consulting firm at 3 sites.

### **Data analysis**

Samples of the contaminated media were handled and analyzed in accordance with New Jersey Department of Environmental Protection and Energy (NJDEP) guidelines. Several USEPA approved analytical methods were used (Table 1). Volatile Organic (VOC) and Base Neutral (BN) compounds, including 15 Tentatively Identified Compounds (TIC), were determined in sludges and soils using USEPA methods SW-8240 and SW-8270 (USEPA 1986). VOC's and BN compounds in drywell liquid and ground water samples were determined using USEPA methods 624 and 625 (USDA 1990), including analyses for 15 TIC's.

### **Data groups**

A total of 274 organic compounds were identified in the contaminated media of the drywell systems. The 274 compounds were subdivided into 4 groups based on the analytical methods used to identify them. Positively identified VOC's (targeted), plus 15 TIC's, determined using methods 4 and 6 in Table 1, are henceforth referred to as the "VOC/TIC" analytical method group. Positively identified BN's (targeted) plus 15 TIC's, determined using methods 5 and 7 in Table 1, are called "BN/TIC". The analytical method groups called "Targeted VOC" and "Targeted BN" were obtained by reporting only the targeted compounds, disregarding the TIC's, from results of analytical methods 4, 5, 6 & 7 (Table 1). Targeted compounds reported with concentrations below the method detection limit (MDL) were not repatriated in this study.

The VOC/TIC and BN/TIC analytical method groups were further subdivided into generic compound groups. Such subdivision was necessary because of the large number of compounds detected using the methods and because most of these compounds were identified with a low degree of certainty. Of the 274 compounds detected, 257 were reported as either "tentatively identified" (222 compounds) or "unknown" (35 compounds).

The names of these generic compound groups are listed in Table 3. Aliphatics have been divided into three sub-groups: ALIPHATICS1 are aliphatic compounds containing only hydrogen and carbon atoms; ALIPHATICS2 are aliphatic compounds with substituted isocyanato, methyloxy or ethyloxy groups; ALIPHATICS3 are aliphatic compounds with at least one substituted chlorine atom. All other generic groups are defined on the basis of their functional group, except for silane, cholestanol, xylenes, toluene, and pyrene. Due to the complex nature of the organic contaminants, we would occasionally encounter a compound with two or more functional groups. In those cases, we classified the compound according to its IUPAC name. For example, phenylmethanol is listed under the group of alcohols.

The organic compounds and generic groups in the contaminated drywell media are presented in Tables 2, 3, and 4. In Table 2, we present the total concentration of BN/TIC and VOC/TIC detected at each facility in each media. In Tables 3 and 4, we present 3 statistics for each compound and generic group identified: maximum and minimum percentages, number of samples, and maximum concentrations. These statistics are given for all contaminated media except for soil. Percentages in the "Maximum %" column for each media were obtained by determining at each site the proportion that each generic group or specific compound contributed to the total concentration of all generic groups or compounds found in that media. These proportions were converted into percentages and the maximum percentages of each generic group or targeted compound were selected for the "Maximum %" column. For example, the generic group ALIPHATICS1 were detected in the DWLIQUID at 4 sites using the VOC/TIC analytical method. At these sites, ALIPHATICS1 contributed 6.6%, 4.7%, 13.8%, 86.3%, of the total contaminants measured as generic groups in the DWLIQUID. Therefore, the maximum percentage of aliphatics in this instance was reported in Table 3 as 86%. Minimum percentages were determined in a similar fashion. They are zero when not reported. The number of times a specified compound or group was analyzed is denoted as "N", with the number of detections in parentheses. The maximum concentration of a targeted compound or generic group is also given.

## RESULTS AND DISCUSSION

### Occurrence and Distribution of Organic Contaminants

As the waste liquid moves through the dry well system, physical, chemical, and biological processes occur which presumably alters the nature and concentration of the wastes. Evidence of such processes and alterations are presented in Tables 3 and 4 and is discussed in the following sections, with respect to analytical method groups.

#### BN/TIC Generic Compound Groups

ALIPHATICS1 were the most commonly occurring generic group of contaminants in the DWLIQUID. ALIPHATICS1 were found 6 of 6 times sampled, and comprised a maximum of 92% of the total contaminants. In the DWSLUDGE, ALIPHATICS1 were found at all 4 sampled sites, and comprised as much as 88% of the contaminants. ALIPHATICS1 were less frequently found in the GROUNDWATER, at only 3 of 8 sites. In GROUNDWATER, ALIPHATICS1 constituted a maximum of 30% of the contaminants. The maximum concentration of ALIPHATICS1 detected were  $53 \times 10^6$  ug/L in the DWLIQUID (Facility #8),  $2 \times 10^8$  ug/L in the DWSLUDGE (Facility #4), but at a low maximum value of 39 ug/L in the GROUNDWATER (Facility #5).

The benzene generic group was also found frequently in all contaminated media of the drywell. The benzene group was found in 6 of 6 samples in the DWLIQUID, 3 of 4 in DWSLUDGE, and 4 of 8 in the GROUNDWATER. The benzene group had total concentrations as high as 501,000 ug/L at one site. However, as with aliphatics, the highest maximum concentration was found in the DWSLUDGE, and the lowest concentrations were found in the GROUNDWATER.

Most of the other contaminants were less frequently found in the contaminated media. The reported group "unknowns" were much more common in the GROUNDWATER than in the other two contaminated media and comprised as much as 100% of the total contaminants identified at one facility.

#### VOC/TIC Generic Groups

ALIPHATICS1, benzenes, xylenes and toluene were consistently the most commonly found VOC/TIC generic groups in the three contaminated media, and they were detected in all three, at almost every tested site. They not only were found frequently, but in many cases, they comprised a major proportion of the contaminants detected. The group "benzenes" for example, was nearly always found, and comprised a maximum of 61% of total contaminants in the DWLIQUID, 49% in the DWSLUDGE, and 99% in the GROUNDWATER. Again, maximum benzene concentrations were highest in DWSLUDGE, and lowest in GROUNDWATER.

#### Targeted BN Organic Compounds

The compounds bis(2-ethylhexyl)phthalate, naphthalene, pyrene, and n-nitrosodi-n-propylamine are the only Targeted BN compounds identified at the tested sites. Bis(2-ethylhexyl)phthalate comprised 100% of the total BN contaminants in the DWLIQUID and DWSLUDGE at one facility. This phthalate was also the contaminant found most frequently in the dry well system. The phthalate and naphthalene were the only two BN compounds identified in the GROUNDWATER.

#### Targeted VOC Organic Compounds

We identified only 14 Targeted VOC's in the dry well systems. The two compounds, xylene and toluene, were encountered most frequently in all three contaminated media. They were found in the DWLIQUID at 4 of 5 sites and in the DWSLUDGE in 2 of 2 sites. Xylenes were identified in the GROUNDWATER at 5 of the 8 sites and toluene was found at 4 of 8 sites. Additionally, xylenes and toluene usually comprised a major proportion of the total Targeted VOC contaminants. At one site in GROUNDWATER, xylene comprised as much as 100% and toluene comprised 48% of the total Targeted VOC. However, these two contaminants usually comprised about 20 to 40% of the total GROUNDWATER VOC contamination at each site. Benzene contributed a maximum of only 9.1% of the VOC in the DWLIQUID at any one site, but was a significant part of the GROUNDWATER contaminants, occurring at a maximum of 39.1% at one site. Benzene was detected in

the GROUNDWATER and the dry well liquid at more than 50% of the tested sites. Interestingly, benzene was not identified in either of the sludge samples tested, but ethyl benzene showed a distribution pattern similar to benzene in the DWLIQUID and GROUNDWATER, and was found at a higher maximum concentration in these dry well contaminated media than benzene. In addition, ethyl benzene was found in the sludge at both tested sites.

### **Source of Organic Contaminants**

We considered the individual targeted contaminants identified, to determine if they were likely to be associated with automotive service stations. Sixteen of the 18 compounds are used in pumps, in motor fuels, as solvents, as degreasers, or in paints and adhesives. All of these products are easily associated with automotive repair and servicing. Two compounds however, *n*-nitrosi-*n*-propylamine and 1-dichlorobenzene, are herbicides and pesticides and are not easily associated with automotive service. Their existence cannot be explained.

### **Fate of Contaminants**

In order to discuss the fate of the contaminants, it is first useful to describe the dry well system, its use, and design features. Usually floor drains exist in garages that service automobiles. The purpose of the floor drain is to capture any liquids escaping from rain and snow drips, petroleum spills, paint and solvent deposition, and floor washing. Depending on how carefully a facility avoids releases of petroleum products and solvents, the DWLIQUID can range from mostly water to highly contaminated. Once the contaminated water enters the floor drain system, it may flow into a tank or directly into a permeable pit (dry well) or leach field (Fig. 1). Due to the functional characteristics of the various components, contaminants occur at different concentrations throughout the system.

As shown in Table 2, contaminants exist in large quantities in DWLIQUID and DWSLUDGE, but are less prevalent in the GROUNDWATER. Biological, chemical and physical processes may be responsible for this decrease in total concentration of contaminants. Volatilization of VOC contaminants may occur during residency of the effluent in the drywell or in the soil vadose zone. The high concentration of contaminants in the DWSLUDGE provides evidence for both physical settling and partitioning, because the sludge is heavier than the DWLIQUID, and because the DWSLUDGE provides a mineral or organic substrate for partitioning. Attenuation of contaminants in soil may be occurring due to partitioning of organic contaminants by sorption onto a substrate, especially when the organic matter content is greater than 0.1% (Feenstra et al. 1991; Hunt et al., 1988), but levels that high are unlikely in most aquifers. Research has shown (Anderson et al., 1991; Wilson et al., 1986) that benzene, toluene, and xylene all disappear rather quickly in soils when biological processes are active. We assume that in most cases, since drywell systems are typically in the vadose zone, contaminant degradation follows the aerobic biological pathway, resulting in a rather rapid degradation rate. In addition, dispersion in the ground water (Mills, 1985) may further reduce the concentration of contaminants.

Evidence of attenuation by soil, by either biological or other processes is demonstrated by Fig. 2, in which the sum of Total VOC/TIC and BN/TIC compounds are plotted on logarithmic axes, with respect to the depth of soil between the bottom of the drywell and the water table. Although a wide range of values occurs between the upper and lower 95% confidence intervals of a linear regression line, there is a strong correlation ( $R^2=0.84$ ). For example, at a depth of 0.3 m, the contaminant concentration could range between 15000 and 900 ug/L, with a 95% probability. We did not include the point situated at the approximate coordinate 15 meters and 13000 ug/L to develop this equation. This data point indicates that the concentration of ground water contamination is much greater than that predicted by the model. One explanation for this outlier could be that the associated high concentration of contaminants (1,720,000 ug/L) in the DWLIQUID at this site have completely overwhelmed the soil's attenuation capacity. The DWLIQUID concentration at this site is significantly higher than the DWLIQUID concentration found at all other sites for which ground water data exists.

We were unable to estimate the maximum concentration of the contaminants in the DWLIQUID which does not overload the attenuation capacity of the soil. However, the site with the highest concentration of contaminants in the drywell which apparently did not overload the soil was site #4, with a DWLIQUID

concentration of 340,000 ug/L of VOC/TIC plus BN/TIC, 250,000 ug/L of BN/TIC, and 90,000 ug/L of VOC/TIC. Because of the uncertainty of when to apply the model, the equation should be used with caution. To remove the uncertainty, more study is required concerning the relationship between contaminants in the GROUNDWATER with respect to contaminants in the DWLIQUID or DWSLUDGE. We attempted to find such a relationship with the available data but found a poor correlation. We may have been more successful with a larger data set (only 5 sites had DWLIQUID and GROUNDWATER data). Furthermore, we did not have data available to consider the soil physical and chemical properties. This matter is a possible subject for further research.

## **Remedial Considerations**

### Considerations Based on Federal Standards

Federal standards generally require some level of remediation of hazardous waste facilities under the authority of the RCRA program (40 CFR Part 264). In order to determine if 5X28 Drywells contain hazardous waste, one must compare contaminant concentrations against the Toxic Characteristic Leaching Procedure (TCLP) criteria, 40 CFR, Part 261, Appendix II. Five sites reported enough data to allow a TCLP based hazardous waste classification of the DWLIQUID. Of these five sites, the DWLIQUID of sites #1 and #4 were determined to contain hazardous waste (Table 6). Two sites reported enough data to allow approximate classification of the DWSLUDGE<sup>1</sup>. At both of these sites (#1 and #2) the DWSLUDGE was classified as hazardous. By this small sample, 60% of the drywells would be classified as Class IV wells using the TCLP test criteria.

### Considerations Based Upon Ground Water Quality

The need to remediate a site should not be based solely on Federal regulations. The focus of the Federal standard is to determine that the waste poses a hazard; then based on the degree of risk, a remedial plan is conceived and executed.

Perhaps the most important risk is to ground water, since the waste itself is generally not situated where it can easily be contacted by touch. Thus, the need to remediate a site will usually be based on ground water quality. The determination of a need to remediate though is less straight-forward than simply determining the implied need to remediate based on the results of the waste classification.

First, there is a need to determine if the contamination is likely to impact a receptor. Clearly, there must be a site investigation; often costly and based on collection of site specific ground water quality information. This risk based approach to determine the need to conduct ground water remedial actions is not new to a state like New Jersey. New Jersey has well developed Ground Water Quality Standards (N.J.A.C. 7:9-6, <http://www.state.nj.us/dep/dwq/rules.htm>) and cleanup standards (N.J.A.C. 7:26C and E, <http://www.state.nj.us/dep/srp/regs/regsinfo.htm>). For example, using potable standards as ground water remediation standards may be viewed as unreasonable if there are no nearby human receptors. Therefore, a cleanup standard less stringent than a potable standard is often applied in areas where contaminants will degrade sufficiently before reaching a potable well. However, before applying such standards, one must consider that there are other ecosystem receptors in addition to humans, and that a contaminant plume can migrate long distances and can impact human receptors far away from the source. Thus, since Federal and State ground water quality standards and approaches to remediate ground water and are not always equivalent, one cannot make a statement that all 5x28 wells must be remediated, because State and Federal rules are not always comparable.

In Table 7, potable standards and hypothetical cleanup standards were used to evaluate whether or not remediation of the ground water is required. By this evaluation, 5 of 8 sites would need to be remediated based upon the potable standard for benzene. However, considering that the monitoring wells were placed very close

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<sup>1</sup> hazardous classification was determined by applying TCLP standards to data collected using USEPA methods 8270 & 8240.

to the drywells, a less stringent standard could be applied to determine the need to remediate. Three hypothetical Cleanup standards were considered. If a standard of 100 ug/L of total BN/TIC plus VOC/TIC is used, 4 sites out of 8 would potentially require ground water remediation. Only 2 sites require remediation when a 10,000 ug/L standard is applied.

### Considerations Based Upon Economics

Remediation of a 5X28 site can be extremely expensive, depending upon the extent of remediation required. It is reasonable for a regulatory agency to require only the extent of remediation that is both cost beneficial and protective of the human health and environment.

The first step in a 5X28 site remediation is to cease discharge. This step is relatively inexpensive, as it may require only the establishment of new protocols for disposing of liquid automotive wastes. Ceasing to discharge eliminates the injection of future sources of contaminants, but does nothing to eliminate the existing contaminants, which may be violating water quality or other standards. Elimination of the existing contaminants potentially consists of several phases. The first phase is to clean out the floordrain and piping, drywell liquid, and sludge. The second phase is to excavate and remove any contaminated soils. The third phase would be to determine the existence of ground water pollution, and to monitor or remediate it as necessary.

To assess the most cost efficient and environmentally effective level of remediation required to address the existing contaminants we calculated the mass of bis(2-ethylhexyl)phthalate in the DWSLUDGE and in the soils at site #4 and the costs to remove the pollutants. We then determined the point at which the ratio of costs to mass of pollutants removed increases dramatically. Site #4 was selected for this analysis because it was the only site that included data from the DWSLUDGE, the GROUNDWATER and the soil (Table 7). The soil samples were collected at various depths from a boring drilled in the vicinity of the dry well, and the ground water sample was collected from a monitoring well installed in that boring. Bis(2-ethylhexyl) phthalate was the only compound detected in the soil which was suitable for this study. It is the only compound which we are fairly certain entered the soil only from discharges via the dry well system. It was also not likely to be volatilized during soil sampling and it exhibited a distribution pattern in the soil column similar to other detected compounds. Furthermore, the results of this study indicates that bis(2-ethylhexyl)phthalate is commonly found in dry well systems. We recognize that bis(2-ethylhexyl)phthalate is sometimes found to be a common laboratory contaminant, associated with plastic, but trip blanks and good quality assurance techniques were employed to preclude that background contamination problem.

Figure 3 portrays the various phases of a remediation project of the drywell system in terms of costs versus percent of pollutants removed. We did not consider ground water remediation in this figure because the pollutants discharged into the soil appeared to be retained by the soil and had not entered the ground water (except for 5 ppb of an unknown compound). A discussion of the data presented in this graph follows.

The "no action" decision coinciding with a decision to cease discharge (Point A, Fig. 3), requires no expenditure and removes none of the contaminants, but may result in a long term environmental improvement due to natural degradation processes.

Closing the drywell system (Point B, Fig. 3) costs about \$5000, and resulted in removal of more than 15% of the pollutants. Depending on the extent of contamination existing in the soils and ground water, this may be an adequate degree of remediation. Removal of 80% of the contaminants can be achieved by remediating to the next phase, identified on Fig. 3 as Point G. Point G could be achieved by removing the contaminated soils within about 0.3 meters of the drywell system. The extra cost required to move from Point B to Point G is moderate; about \$8,500. However, to require the final 20% of pollutant removal becomes prohibitively expensive after Point F, because at the base of the drywell, the contaminant plume is projected to become "bell shaped", and a substantial excavation and removal of soil would be required, resulting in a large expense to dispose of the contaminated soil.

The point where the amount of pollutants removed no longer becomes beneficial from a cost perspective can be quantified by calculating a ratio based upon a formula described by Guthrie and Wallace (1969) and used

in economic analyses to measure elasticity of demand. The ratio is the percentage increase in pollutants removed divided by the percentage increase of expenditure to remove those pollutants. Ratios with values of 1 or greater mean that the increase in remediation costs resulted in a proportional or more than proportional increase in the amount of pollutants removed. On the other hand, ratios less than 1 mean that the increase in cost in remediation to the next higher level was accompanied with a less than proportional increase in pollutants removed. In other words, the smaller the ratio, the less efficient the cleanup becomes in terms of pollutants removed versus costs. For the site under consideration, this ratio drops from 9.9 at point G to 0.12 at the next remediation level. These ratios for the entire remediation project are also presented in Figure 3.

At any point in the remediation process, a monitoring well system could be installed. For minimal additional cost on a dollar basis, a substantial increase in the knowledge base can be achieved. For example, at Point B, a well could be installed for \$2,000 to \$10,000, which, while it would double the cost to achieve that level of remediation, could be used to ascertain no need to remove soil. Installation of a monitoring well at Point G could be used in conjunction with the 80% removal of contaminants to ensure that there is no lingering contamination of the ground water. The additional cost for this level of assurance at Point F, would be only 30% more expensive, but appears to be more reasonable than to require removal of all the contaminated soil.

### **CONCLUSION**

This study of 5X28 automotive waste disposal drywells provides evidence that they are a threat to the nation's ground water resources. Contamination of the drywell contaminated media with aliphatics, benzenes, xylenes and toluene is prevalent. The data exhibited a high degree of variance, indicating that our sample of 10 drywells was not adequate to enable us to portray the chemical signature of an "average drywell." In fact, there may not be "an average 5X28 drywell" due to the nearly unlimited potential for different waste disposal practices.

We determined that 60% of the 5X28 drywells can be classified as Class IV injection wells, using a simple comparison of the constituent concentrations against the TCLP criteria. Although soils are fairly effective at attenuating contaminants as they travel from the drywell to the ground water, we determined that at 50% of the drywell system sites, ground water closely adjacent to them exceeds potable standards for benzene and xylene. When less stringent ground water cleanup standards are considered, at least 2 of 8 facilities may require some form of ground water remediation in accordance with New Jersey cleanup levels..

Effective remediation of 80% of the contaminants can be implemented by ceasing to operate, removing liquid and sludge from the drywell system, plugging the drywell, and by excavating the soil within about 0.3 meters of the drywell. For a minimal additional cost, a single monitoring well can be installed, which will help determine the need for additional ground water remedial action.

The findings of this study can be useful for anyone planning to implement closure or remediation of 5X28 drywells. The knowledge that ground water can be relatively free of contaminants, depending on the depth of soil between the base of the drywell and the water table, can be used to prioritize cases, based upon the depth to a water table. The knowledge of costs to remediate to certain levels can be used to predict the economic impact on the regulated community. Knowledge of this type can be used to establish a reasonable balance between the need to protect the environment and the need to minimize impact to the responsible parties.

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Table 6. Criteria for Classification of Drywells as Class IV wells.

Table 7. Assessment of need to remediate groundwater based on two standards.

Table 1. Analytical methods used to evaluated potentially contaminated media of drywell systems.

Facility ID	Contaminant Phase Sampled			
	Liquid	Sludge	Soil	Groundwater
Methods				
1(4440)	4,5	4,5	0	6,7
2(4445)	6,7	4,5	0	6,7
3(6481)	N	N	0	6,7
4(4898)	6,7	5	7	6,7
5(6107)	6,7	6,7	N	6,7
6(s&M)	N	N	N	6,7
7(2535)	N	N	4,5	N
8(5472)	6,7	5	6,7	N
9(2753)	N	N	0	6,7
10(2547)	7	N	N	6,7

Notes: 0=Partial VOC (BTEX); 2=VOC (SW8240);

3=BASE NEUTRAL (SW8270); 4=VOC/TIC (SW8240+15); 5=BASE NEUTRAL/TIC (SW8270+15);

6=VOC/TIC (EPA624+15); 7=BASE NEUTRAL/TIC (EPA625+15); N=not tested

TABLE 2. Total Organic Compound Concentrations In a Dry Well System

SITE #	Contaminant Concentrations (ug/kg)			
	DWLIQUID	DWSLUDGE	GROUND WATER	SOIL
<b>BN/TIC Group</b>				
1	1,613,000	1,729,000	2,784	NT
2	1,651	373,700	183	NT
3	NT	NT	55	NT
4	250,896	240,000,000	5	10,833(1)
5	12,980 (2)	**	670(3)	NT
6	NT	NT	9(4)	NT
7	NT	NT	NT	5,000(5)
8	61,200,000(2)	7,810,000	NT	240(6)
9	NT	NT	84(7)	NT
10	12,486	NT	8.7	NT
<b>VOC/TIC Group</b>				
1	110,200	257,700	19,420	NT
2	1,271	962,000	933	NT
3	NT	NT	18,141	NT
4	88,330	NT	0	NT
5	6,708(2)	**	1265	NT
6	NT	NT	0(4)	NT
7	NT	NT	NT	43,400(5)
8	3,930,000(2)	**	NT	17,640(6)
9	NT	NT	291(7)	NT
10	NT	NT	15.3	NT

**NT -NOT TESTED**

Unless otherwise indicated, data obtained from analytical results of 1 sample.

(1) average of analytical results of 3 soil samples collected at depths of 6 feet, 15 feet, and 22 feet below ground surface

(2) analytical results of combined DWLIQUID and DWSLUDGE sample

(3) 2 monitoring wells installed near dry well were sampled concurrently: result of ground water sample with highest concentration reported

(4) monitoring well sampled on 2 occasions; result of ground water sample with highest concentration reported

(5) soil samples collected from bottom of dry well

(6) post-excavation soil samples results

(7) reported ground water concentration estimated from results of samples collected from 2 monitoring wells installed near dry well

Table 3. Generic Groups of Organic contaminants Identified in Automotive Drywell System Contaminated media.

CHEMICAL NAME	Drywell Liquid				Drywell Sludge				Ground Water			
	Maximum %	Minimum %	N	Maximum Concen- tration	Maximum %	Min- imum %	N	Maximum Concen- tration	Max- imum %	Minimum %	N	Maximum Concen- tration
<b>BN/TIC<sup>1</sup></b>												
unknowns	0	0	6(0)	0	4	0	4(1)	9.7E6	100	0	8(3)	24
ALIPHATICS1	92	10	6(6)	53E6	88	34	4(4)	2E8	30	0	8(3)	39
ALIPHATICS2	10	0	6(2)	6.2E6	15	0	4(1)	1.2E6	0	0	8(0)	0
phthalates	4	0	6(3)	69000	4	2	4(3)	9.4E6	2	0	8(1)	10
alcohols	55	0	6(2)	2840	10	0	4(1)	770000	100	0	8(3)	421
aldehydes	2	0	6(1)	33	0	0	4(0)	0	0	0	8(0)	0
ketones	0	0	6(0)	0	0	0	4(0)	0	31	0	8(2)	52
organic acids	35	0	6(1)	4540	0	0	4(0)	0	0	0	8(0)	0
naphthalenes	6	0	6(1)	94000	9	0	4(3)	670000	10	0	8(2)	300
benzenes	31	0	6(4)	501000	51	4	4(3)	1.1E7	100	0	8(4)	2484
heterocyclics	10	0	6(2)	2E6	0	0	4(0)	0	8	0	8(1)	15
phenols	0	0	6(0)	0	4	0	4(1)	16000	0	0	8(0)	0
silanes	0	0	6(0)	0	0	0	4(0)	0	2	0	8(1)	16
cholestanol	7	0	6(1)	875	0	0	4(0)	0	0	0	8(0)	0
iron compounds	21	0	6(2)	340000	6	0	4(1)	110000	0	0	8(0)	0
amines	1	0	6(1)	71	0	0	4(0)	0	0	0	8(0)	0
pyrene	3	0	6(1)	48000	0	0	4(0)	0	0	0	8(0)	0
<b>VOC/TIC2</b>												
unknowns	29	0	5(3)	1938	3	2	2(2)	18000	11	0	6(3)	1740
ALIPHATICS1	86	0	5(4)	339000	22	4	2(2)	55700	100	0	6(4)	845
ALIPHATICS2	66	0	5(1)	830	0	0	2(0)	0	5	0	6(2)	130
ALIPHATICS3	29	0	5(2)	26000	16	4	2(2)	42000	0	0	6(0)	0
alcohols	19	0	5(2)	1300	1	0	2(1)	3400	30	0	6(1)	87
aldehydes	1	0	5(1)	6	0	0	2(0)	0	0	0	6(0)	0
ketones	14	<1	5(5)	40000	5	0	2(1)	48000	0	0	6(0)	0
organic acids	3	0	5(1)	200	3	0	2(1)	6600	0	0	6(0)	0
naphthalenes	13	0	5(1)	500000	0	0	2(0)	0	0	0	6(0)	0
benzenes	61	0	5(4)	67400	49	21	2(2)	469000	99	0	6(5)	18000
xylenes	28	0	5(4)	25000	31	26	2(2)	300000	44	0	6(5)	8600
heterocyclics	2	0	5(2)	2000	1	0	2(1)	2200	1	0	6(1)	160
ethers	6	0	5(3)	720	0	0	2(0)	0	33	0	6(2)	96
toluene	13	0	5(4)	11000	7	5	2(2)	50000	48	0	6(4)	3200

<sup>1</sup>Base Neutral Compounds plus 15 tentatively identified compounds, as determined by USEPA method 625+15, and SW 8270

<sup>2</sup>Volatile Organic Compounds plus 15 tentatively identified compounds, as determined by USEPA methods 624+15 or SW8240; ALIPHATICS1 are aliphatic compounds containing only hydrogen and carbon atoms; ALIPHATICS2 are aliphatic compounds with substituted isocyanato, methyloxy or ethyloxy groups; ALIPHATICS3 are aliphatic compounds with at least one substituted chlorine atom

Table 4. Distribution of Specific Targeted Organic Compounds Identified in contaminated media of 5X28 Drywell Systems.

	Liquid			Sludge			Ground Water		
Compound	Max- imum <sup>1</sup>		Maximum Concen- tration	Max- imum <sup>1</sup>		Maximum Concen- tration	Max- imum <sup>1</sup>		Maximum Concen- tration
	%	N <sup>2</sup>	ug/L	%	N <sup>2</sup>	ug/L	%	N <sup>2</sup>	ug/L
Base Neutral Compounds <sup>3</sup>									
bis(2-ethylhexyl)phthalate	100	6(3)	69000	100	4(3)	9.4E6	45.5	8(1)	10
naphthalene	27.8	6(1)	45000	100	4(2)	1E5	100	8(2)	300
pyrene	29.6	6(1)	48000	0	4(0)	0	0	8(0)	0
n-nitrosodi-n-propylamine	100	6(1)	71	0	4(0)	0	0	8(0)	0
Volatile Organic Compounds <sup>4</sup>									
p,o-xylene	37.9	5(4)	13000	37.6	2(2)	160000	100	8(5)	4200
m-xylene	25.3	5(4)	14000	32.9	2(2)	140000	32.3	8(4)	4400
toluene	38.7	5(4)	11000	13.5	2(2)	50000	48.2	8(4)	3200
benzene	9.7	5(3)	650	0	2(0)	0	39.1	8(4)	530
ethyl benzene	9.1	5(3)	4800	9.2	2(2)	39000	19.5	8(4)	1300
methyl tert butyl ether	13.7	4(2)	720	0	2(0)	0	43.2	6(2)	96
trichloroethylene	4.7	5(2)	2200	29.9	2(2)	42000	0	8(0)	0
1,1,1-trichloroethane	9.4	5(1)	6500	0	2(0)	0	0	8(0)	0
1,2-dichlorobenzene	1.4	5(1)	940	1.6	2(1)	2300	6.5	8(1)	82.5
methylene chloride	22.7	5(1)	7800	4.9	2(1)	21000	0	8(0)	0
tetrachloroethylene	23.2	5(1)	16000	0	2(0)	0	0	8(0)	0
trans-1,2-dichloroethylene	1.9	5(1)	1300	0	2(0)	0	0	8(0)	0
tertiary butyl alcohol	0	5(0)	0	0	2(0)	0	39.5	8(1)	87
1,4-dichlorobenzene	0	5(0)	0	0	2(0)	0	1.5	8(1)	18.5

<sup>1</sup>This column lists the maximum percentage of the total contaminants contributed by the listed contaminant, calculated as a fraction of the total contaminants determined by the underlined method.

<sup>2</sup>N is the number of samples included in averaging; Numbers in parentheses indicates the number of samples with reported levels above MDL

<sup>3</sup>Determined using USEPA methods 625 or SW 8240

<sup>4</sup>Determined using USEPA methods 624 or SW 8270

Table 5. Distribution of Bis(2-Ethylhexyl)Phthalate in the contaminated media of a Drywell System

Drywell Component	Sample Depth meters	Concentration ug/L
Drywell Liquid	2.3-2.4	6400
Drywell Sludge	2.4-2.7	9400000
Soil Above Base of Drywell	0-3.3	0
Soil Below Base of Drywell	4.6	9900
Soil Below Base of Drywell	6.1	4600
Ground Water	9.4	0

Table 6. Criteria for Classification of Drywells as Class IV wells.

Compound	Standard mg/L	Liquid		Sludge	
		Number	Number <sup>2</sup> Tested Hazardous	Number	Number <sup>2</sup> Tested Hazardous
Benzene	0.5	5	1(4)	2	0
tetrachloroethylene	0.5	5	1(4)	2	0
trichloroethylene	0.7	5	2(1,4)	2	2(1,2)

<sup>1</sup>(USEPA 1989)<sup>2</sup>Site numbers are in parentheses.

Table 7. Assessment of need to remediate groundwater based on two standards.

Compound	Standard	Number Tested	Number Requiring Remediation <sup>2</sup>
Potable Standards ug/L <sup>1</sup>			
Benzene	1	8	4(1,2,5,9)
Xylenes	44	8	2(1,5)
Hypothetical Cleanup Standards mg/L			
Total BN/TIC&VOC/TIC <sup>1</sup>	100	8	5(1,2,3,5,9)
Total BN/TIC&VOC/TIC	1000	8	4(1,2,3,5)
Total BN/TIC&VOC/TIC	10000	8	2(1,3)

<sup>1</sup>USEPA Method 624+15 & 625+15 (USEPA 1990)<sup>2</sup>Site numbers are in parentheses.

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Figure 2. Concentration of Sum of Total VOC/TIC and BN/TIC in ground water with respect to depth of soil between bottom of drywell and top of water table.

Figure 3. Cost to remove pollutants from 5X28 drywells versus the percent of pollutants removed; a measure of remedial efficiency.

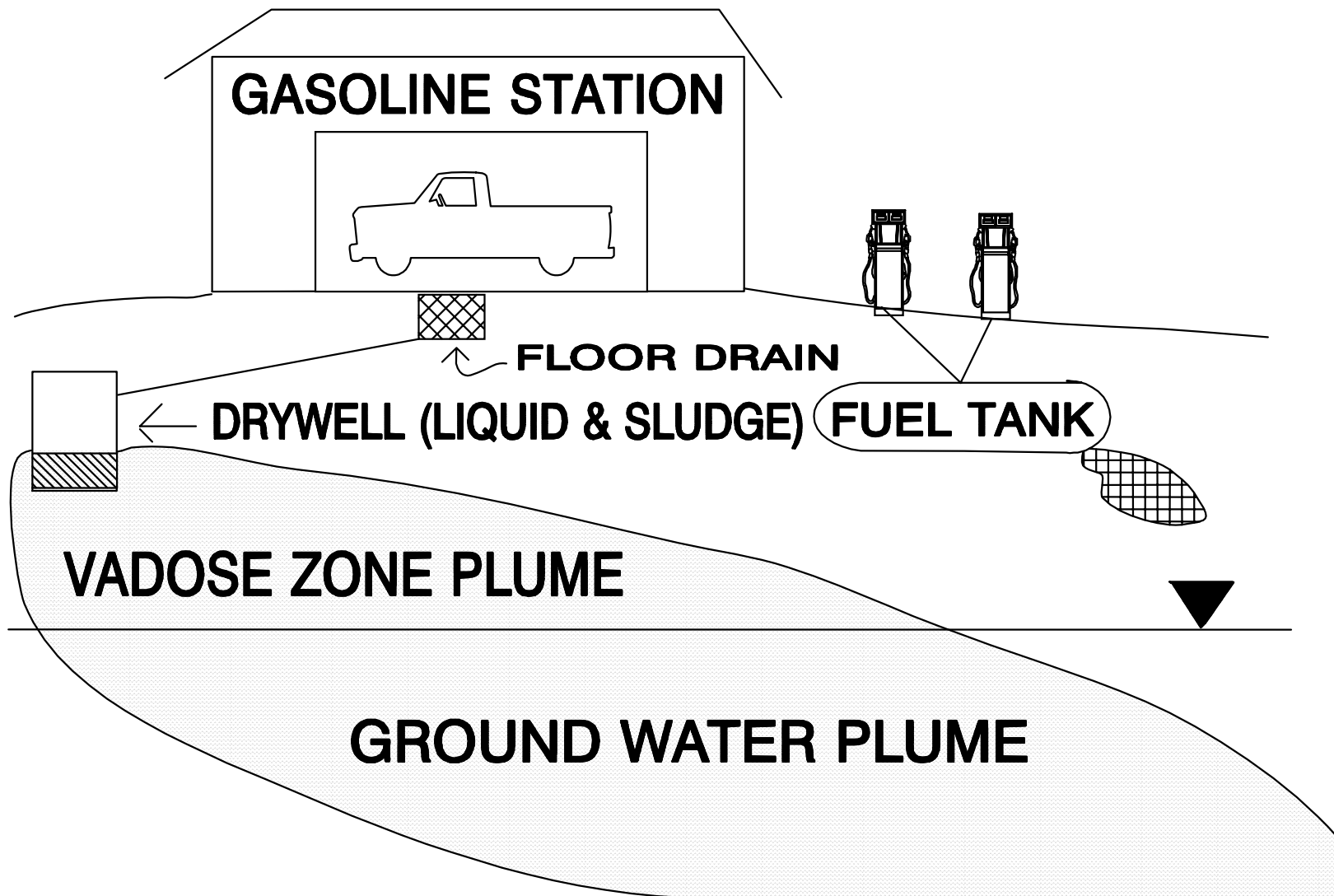


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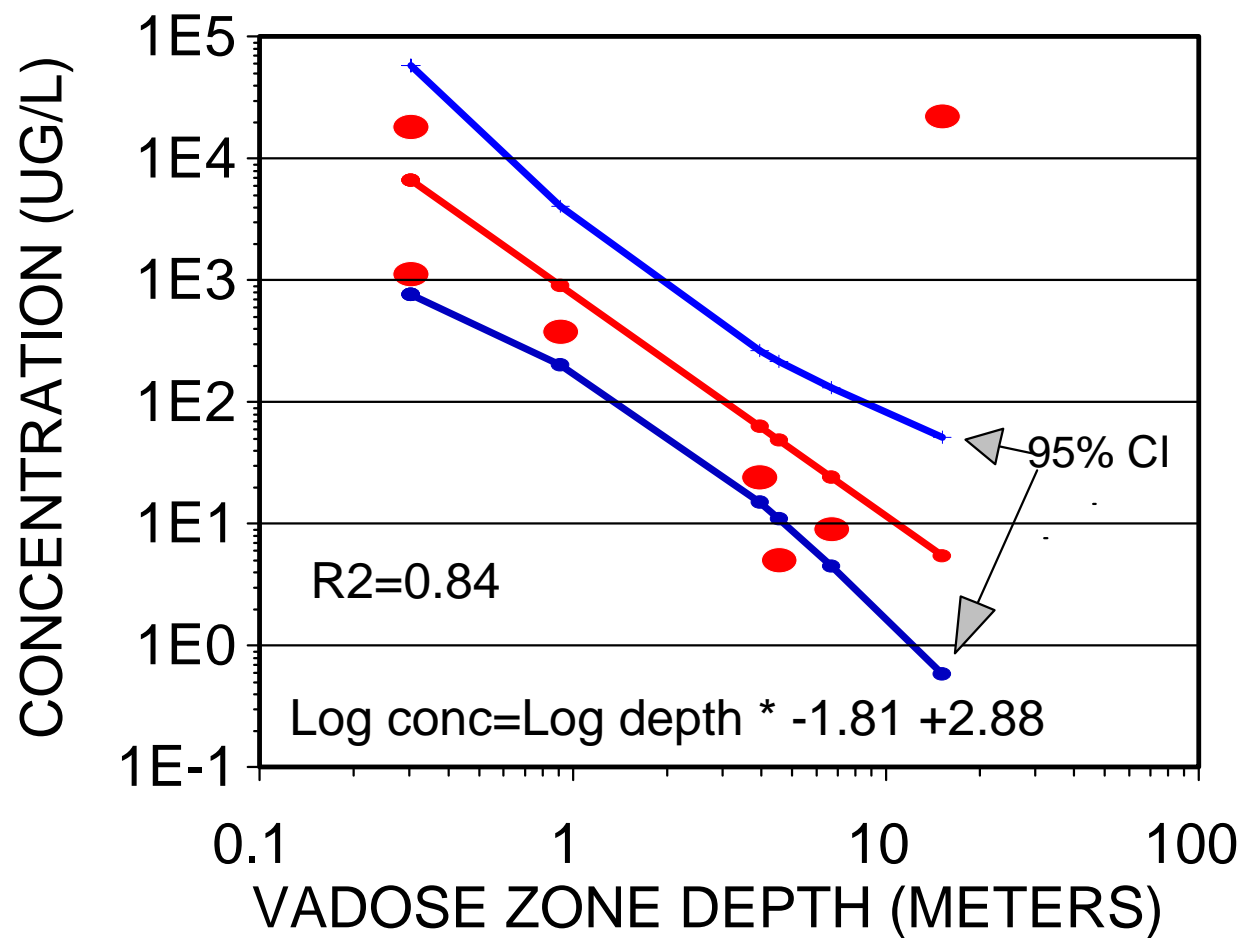


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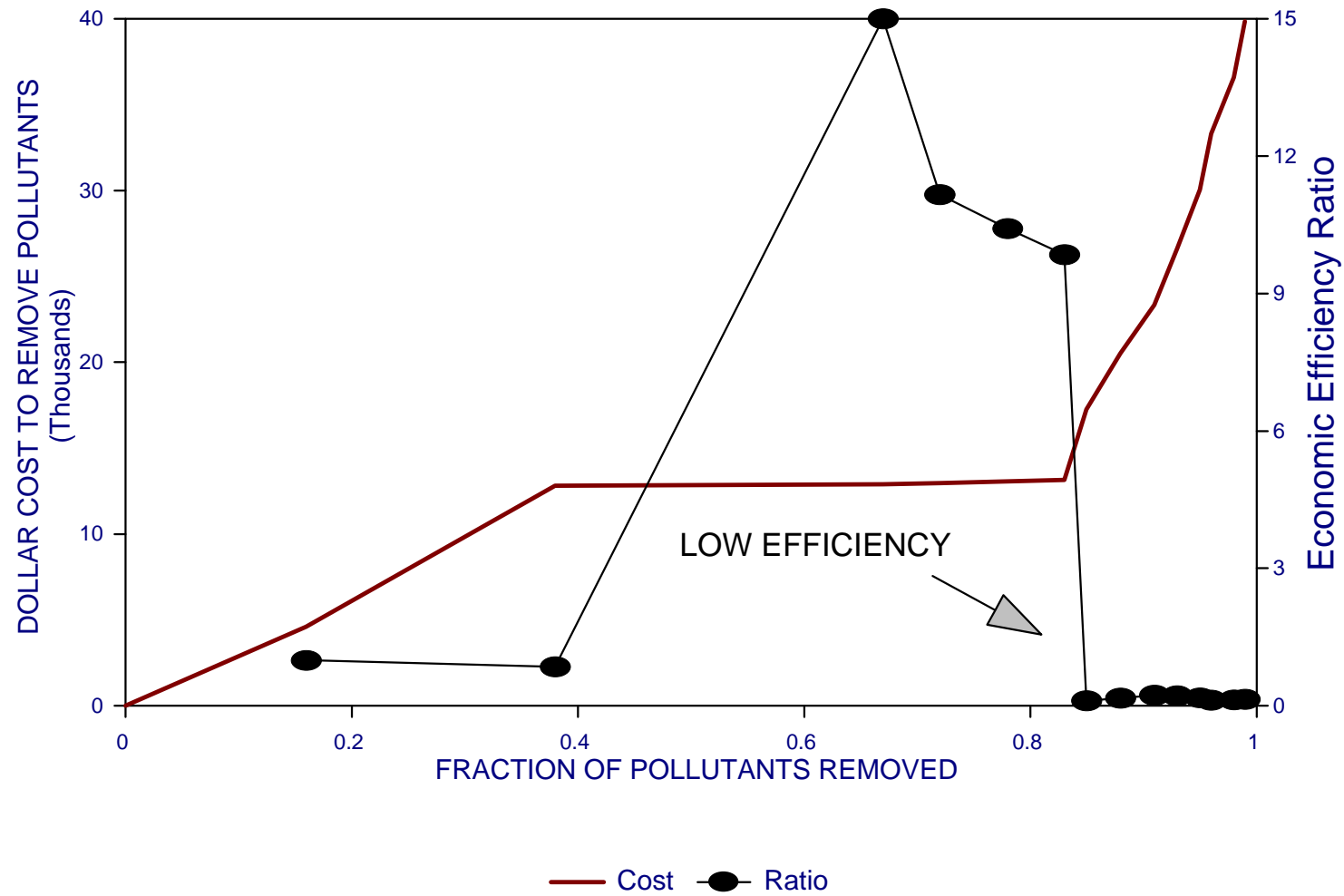


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